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Nutritional and Physical Properties of Honey from Selected Locations in Owerri-West Local Government Area, Imo State, Nigeria

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Abstract
This study evaluated the nutritional and physical properties of honey harvested from selected locations (FUTO, Nekede, Avu and Umuguma) in Owerri-West L.G.A. of Imo State. Samples were analysed for their proximate, mineral, vitamins and physical properties at SAAT Laboratory, FUTO, Owerri. Data were analysed with one-way ANOVA and LSD at α = 0.05. Moisture content of honey samples had a rating of 16.83±0.09 % (Nekede) < 20.17±0.45 % (Umuguma) < 21.33±0.64 % (Avu) < 22.20±0.74 % (FUTO); protein rating of 2.83±0.08 % (Nekede) > 1.52±0.05 % (Umuguma) > 1.25±0.16 % (Avu) > (1.08±0.06 % (FUTO) and brix rating of 82.33±1.45 % (Nekede) > 78.67±1.86 % (Umuguma) > 77.33±1.76 % (FUTO) > 72.67±1.45 % (Avu). Mineral content showed that Avu had the highest mean values of 74.03±0.38ppm, 86.38±0.58 ppm and 22.80±0.97 ppm for Ca, Mg and P respectively. Umuguma had the highest ratings for K (264.63±3.40 ppm) and Cu (0.13±0.01 ppm).Vitamin A had rating of 14.09±0.05 mg/100g (Umuguma) > 14.03±0.03 mg/100g (Nekede) > 13.83±0.09 mg/100g (Avu) > 13.50±0.29 mg/100g (FUTO) and vitamin C values of 22.53±0.15 mg/100g (Avu) > 21.72±0.21 mg/100g (FUTO) >21.63±0.23 mg/100g (Nekede) > 19.40±0.23 mg/100g (Umuguma). For viscosity, FUTO had the highest mean value (1553.33±58.40 cP) while Umuguma recorded the lowest (1460.33±30.18 cP). Mean density values range from 1.57±0.07 g/ml (Avu) to 1.40±0.06 g/ml (Umuguma). Analyses showed that the honey samples were significantly different ($p<0.05$) in proximate compositions but there is no significantly different ($p>0.05$) in minerals, vitamins and physical properties. More studies should be conducted to ascertain the variations in proximate composition among the major agro-ecological zones of Imo State.
Keywords: Honey, proximate composition, mineral, vitamins, viscosity, density

1. Introduction

Honey is a sugary food substance produced and stored by certain social hymenopteran insects, consisting basically of a complex mixture of carbohydrates, especially glucose and fructose, organic acids, amino acids, minerals, vitamins, enzymes, pollens, and pigments (Crane, 1990; Fallico, Arena, and Verzera, 2004). Honey derives its sweetness from the monosaccharide; fructose and glucose, and has approximately the same relative sweetness as that of granulated sugar (National Honey Board, 2012). The average sugar component is

about 76 – 80 percent of pure honey, while water accounts for about 17 – 20 percent (McNulty, 2006). Vitamin C and most of the Vitamin B complex are present in variable amounts (Oszmianski and Lee, 1990). The viscosity of honey is affected greatly by both temperature and water content with its colour forming a continuous range from very pale yellow through amber to darkish red amber to nearly black colour caused by the darkening action of heat (Popek, 2002). Several investigations have shown that the trace element contents of honey depend mainly on the botanical origin of the honey (Feller-Demals, Vincent and Beulieu, 1989). It is the greatest responsibility of bee-keepers to keep honey in its original condition of high quality to retain its mineral constituents. The composition and quality of honey vary, depending on the climatic region, temperature, botanical origin, the honeybees' species, the sugar composition, the treatment of honey during extraction, processing and subsequent storage conditions (Alvarez-Suarez, Tulipani, Bertoli,. and Battino, 2010; Amril and Ladjama, 2013).

The limitation of bee-keeping in Africa, particularly in Nigeria is as a result of the marginal understanding of people towards the practice (Edet, Oladele and Bekom, 2012). Data on bee-keeping in Nigeria especially in Imo State is insufficient. Few data exist on the factors responsible for the variation in honey and as such its suitability for consumption has not been provided. Furthermore, the loss of biodiversity in flora, occasioned by the high rate of deforestation and incessant burning of forest vegetation has always discouraged the practice of bee-keeping in Imo State. This is because of the fact that honey is a forest and wildlife product, and as such, its quality and quantity is dependent more on forest vegetation. The quality of honey is one of the major concerns of honey consumers, regardless of the origin. This is very important for food processing industry, particularly for those industries using honey as an ingredient in their food products.

Honey produced in different localities has distinct indigenous features. This is as a result of variations in weather, climate and botanical distribution. By this, the quality of honey produced from an area/locality cannot be used to determine or extrapolate the quality of honey obtained from another area/locality. From the foregoing, it becomes pertinent that extensive research is necessary to characterize the nutritional and physical properties of honey obtained from various localities. This study, therefore, evaluated the nutritional composition and physical properties of honey obtained from some selected locations in Owerri-West Local Government Area of Imo State, Nigeria.

2. Materials and Methods

2.1. Study Area

This study was carried out in Owerri-West Local Government Area (latitude 5°25' N - 5°45'N and longitude 6°58'E - 7°10'E), Imo State, Nigeria. The Climate of the area is tropical with two seasons, the dry season (November to March) and wet season (April to October). The mean annual rainfall is between 1250 mm and 3000 mm with a relative humidity of about 90% and temperature values of 25°C to 35°C.

2.2. Honey Sample Collection and Analysis

Honey samples were collected from four locations (FUTO, Nekede, Avu and Umuguma) in Owerri-West Local Government Area of Imo State. The honey samples were collected from three bee-keepers in each location. To avoid adulteration, experimental samples were

obtained directly from bee-hives. Samples were taken to School of Agriculture and Agricultural Technology (SAAT) Laboratory, Federal University of Technology, Owerri, Imo State for proximate composition (moisture, ash, protein, fat, brix), mineral (calcium, magnesium, phosphorus and copper), vitamin (A, B_1, B_2, B_3, B_6 B_{12} and C) and physical properties (viscosity and density) analysis as described by the standards of Association of Official Analytical Chemists (AOAC) (2000). Data generated were subjected to one-way analysis of variance (ANOVA) to compare various honey components from different locations. For any significantly different result, Least Significant Difference (LSD) at α = 0.05, was used for mean separation.

3. Results and Discussion

3.1. Proximate composition of honey samples

Table 1: Proximate composition of honey samples collected from various locations in Owerri-west L.G.A.

Locations	%Moisture content	%Ash	%Protein	%Fat	Brix (%)
FUTO	23.45	0.64	1.03	5.66	78.00
	20.89	0.72	1.00	5.78	74.00
	22.25	0.84	1.20	4.99	80.00
Mean±S.E	22.20 ± 0.74^{a}	0.73 ± 0.06^{c}	1.08 ± 0.06^{e}	5.48 ± 0.25^{g}	77.33 ± 1.76^{jk}
Nekede	16.70	0.04	2.97	4.98	80.00
	17.00	0.023	2.84	4.72	82.00
	16.80	0.04	2.69	3.88	85.00
Mean±S.E	16.83 ± 0.09^{b}	0.03 ± 0.01^{d}	2.83 ± 0.08^{f}	4.53 ± 0.33^{h}	82.33 ± 1.45^{j}
Avu	20.30	0.78	1.55	4.03	75.00
	21.20	0.68	1.20	4.05	70.00
	22.50	0.58	0.99	3.98	73.00
Mean±S.E	21.33 ± 0.64^{a}	0.68 ± 0.06^{c}	1.25 ± 0.16^{e}	4.02 ± 0.02^{h}	72.67 ± 1.45^{k}
Umuguma	19.30	0.15	1.43	3.17	81.00
	20.40	0.14	1.52	2.90	80.00
	20.80	0.16	1.60	3.34	75.00
Mean±S.E	20.17 ± 0.45^{a}	0.15 ± 0.01^{d}	1.52 ± 0.05^{e}	3.14 ± 0.13^{i}	78.67 ± 1.86^{jkl}
LSD value	1.76	0.13	0.32	0.71	5.36

NB.: means with the same superscript in the same column are not significantly different, α = 0.05

The highest mean moisture content of 22.20±0.74 % was recorded in FUTO followed by Avu (21.33±0.64 %). The least mean moisture content of 16.83±0.09 % was recorded in Nekede. With respect to ash content, the highest value of 0.73±0.06 % was recorded in FUTO followed by 0.68±0.06 % recorded in Avu. The least value of 0.15±0.01 % was recorded in Umuguma. The result for protein content revealed that honey samples from Nekede had the highest mean value of 2.83±0.08 % followed by Umuguma (1.52±0.05 %). The least value of 1.08±0.06 % was recorded in FUTO. The highest mean fat content of 5.48±0.25 % was recorded in FUTO followed by the value recorded in Nekede (4.53±0.33 %). The least mean fat content of 3.14±0.13 % was recorded in Umuguma. The result for brix content revealed that honey samples from Nekede had the highest mean value of 82.33±1.45 % followed by

Umuguma (78.67±1.86 %). The least value of 72.67±1.45 % was recorded in Avu. With respect to moisture content, the mean value of honey samples from FUTO, Avu, and Umuguma were not significantly different from each other. However, mean moisture content value of honey samples from Nekede significantly differed from those of FUTO, Avu, and Umuguma. Details of the mean separation results are shown in Table 1. The average moisture content of honey samples from the selected locations was found to be within the limit of about 20.00% per 100g according to Codex Alimentarius Committee (2001). The honey samples from FUTO, Avu and Umuguma indicated moisture contents higher than 20.00%. Only samples from Nekede showed moisture contents lower than 20.00% per 100g. The mean values from the four locations fall within the range of moisture contents of 12.5 % to 25.22% as reported by Badawy Shafii.Tharwatt, and Kamal (2004), Oyeleke Dauda, Jimoh, and Musa. (2010) and Buba, Abubakar and Aliyu, (2013). Research has shown that moisture content in honey samples lower than 20.00 % elongates the shelf life of honey (Sohaimy El, Masry and Shehata, 2015), while factors of temperature and relative humidity in the geographical origin affect honey moisture content. The results of the ash content recorded in this study, ranging from 0.15±0.01 to 0.73±0.06% were closely similar to the study of Ayansola and Banjo (2011) that recorded range values of 0.140±0.158 to 0.708±0.754 % from honey obtained in South-Western Nigeria for ash content of sweet honey. The result is also in agreement with the findings of Odeyemi, Adefemi and Adebayo (2013), Agbagwa and Frank-Peterside (2010) and Oyeleke *et al*. (2010).The protein content values of 1.08 % to 2.83 % obtained from the selected locations were higher than those reported by Buba*et al*. (2013) that reported protein content of 0.35 % to 1.08 % in North-East of Nigeria, but close to the study of Agunbiade, Arojojoye and Alao, (2012) that reported protein content values of 1.43 % to 2.72% from three states in Nigeria

The fat content values obtained from the four locations ranges from 3.14 % to 5.48 %, and were higher than those reported by Oyeleke *et al*. (2010) that recorded fat content value of 1.5 % of honey samples obtained in a similar study. This variability could be due to the differences in flora species. The result of the brix content ranges from 72.67 % to 82.33 %, and this was in line with the range of 77.60 % to 87.70 % as prescribed by United States National Honey Board.

The result revealed that there were significant differences ($p<0.05$) among the mean moisture, mean ash, mean protein, mean fat and mean brix contents of honey samples obtained from the locations.

3.2. Mineral content analysis of honey samples

The highest mean calcium of 74.03±0.38 ppm was recorded for Avu followed by Umuguma (72.17±0.90 ppm). The least mean calcium of 70.57±0.38 ppm was recorded in Nekede. With respect to potassium, the highest value of 264.63±3.40 ppm was recorded in Umuguma followed by Nekede (263.87±3.72 ppm). The least value of 255.13±2.93 ppm was recorded in Avu.

The result for magnesium showed that honey samples from Avu had the highest mean value of 86.38±0.58 ppm followed by Nekede (84.78±0.40 ppm). The least value of 84.30±3.16 ppm was recorded for Umuguma. The highest mean phosphorus of 22.80±0.97 ppm was recorded for Avu followed by Nekede (21.77±0.73 ppm). The least mean phosphorus of 21.30±0.47 ppm was recorded for Umuguma. The result for copper showed that honey

samples from Umuguma had the highest mean value of 0.13±0.01 ppm followed by Nekede (0.09±0.003 ppm). The least values of 0.08±0.003 ppm and 0.08±0.01 ppm were recorded for FUTO and Avu respectively.

Table 2: Mineral content of honey samples from the study sites

Locations	Ca (ppm)	K (ppm)	Mg (ppm)	P (ppm)	Cu (ppm)
FUTO	71.30	267.10	88.26	23.20	0.09
	70.00	270.80	84.03	20.00	0.08
	72.00	248.90	78.33	21.70	0.08
Mean±S.E	71.10±0.59^{a}	262.27±6.77^{c}	83.54±2.88^{d}	21.63±0.92^{e}	0.08±0.003^{f}
Nekede	70.40	271.30	85.34	22.90	0.09
	70.00	260.40	84.00	20.40	0.09
	71.30	259.90	85.01	22.00	0.08
Mean±S.E	70.57±0.38^{a}	263.87±3.72^{c}	84.78±0.40^{d}	21.77±0.73^{e}	0.09±0.003^{f}
Avu	74.70	254.50	87.52	24.10	0.09
	73.40	250.40	86.02	20.90	0.09
	74.00	260.50	85.60	23.40	0.06
Mean±S.E	74.03±0.38^{b}	255.13±2.93^{c}	86.38±0.58^{d}	22.80±0.97^{e}	0.08±0.01^{f}
Umuguma	72.40	263.80	90.45	21.50	0.12
	70.50	259.20	80.00	20.40	0.13
	73.60	270.90	82.45	22.00	0.15
Mean±S.E	72.17±0.90^{ab}	264.63±3.40^{c}	84.30±3.16^{d}	21.30±0.47^{e}	0.13±0.01^{g}
LSD value	1.96	14.60	7.08	2.61	0.02

NB.: means with the same superscript in the same column are not significantly different, α = 0.05

With regards to calcium, mean value of honey samples from FUTO, Nekede and Umuguma were not significantly different from each other. However, mean calcium value of honey samples from Avu significantly differed from those of FUTO and Nekede though not significantly different from that of Umuguma. Evaluating copper, the mean value of honey samples from FUTO, Nekede, and Avu were not significantly different from each other but mean copper value of honey samples from Umuguma differed significantly from FUTO, Nekede, and Avu. Details of the mean separation results are shown in Table 2 below.

The results indicated that potassium (K) was the predominant mineral in all the honey samples obtained from the locations, and ranges from 255.13 ppm to 264.63 ppm. This is followed by Mg, Ca, P and Cu. This result is in consonance with the report of Mesallam and El-Shaarawy (1987) that K is one of the predominant elements in honey. The mean values for Ca, Mg and P fall within the range of those of Abdulaziz *et al*. (2012).The mean values of Ca ranges from 70.57 ppm to 74.03 ppm, K from 255.13 ppm to 264.63 ppm, Mg from 83.54 ppm to 86.38 ppm, P from 21.30 ppm to 22.80 ppm and Cu from 0.08 ppm to 0.13 ppm, and were contrary to the study of Akharaiyi and Lawal, (2016) that reported that the Ca, K, Mg, P and Cu content of honey obtained from farmers in the Western States of Nigeria ranged from 50.75 ppm to 58.45 ppm, 475.46 ppm to 486.18 ppm, 25.11 ppm to 28.03 ppm, 27.4 ppm to 32.5 ppm and 0.66 ppm to 1.18 ppm respectively. This variability in mineral content can be

attributed to botanical, environmental and geographical factors (Bogdanov Haldimann, Luginbuhl and Gallmann, 2007; Chua, Abdul-Rahaman, Sarmidi, and Aziz, 2012).

The result revealed that there were significant differences ($p<0.05$) among the mean calcium (Ca) and mean copper (Cu) of honey samples obtained from the locations. However, there were no significant differences ($p>0.05$) in mean magnesium (Mg), mean potassium (K) and mean phosphorus (P) among the locations. The results of mean separations (LSD tests) for the mineral content of honey samples from the selected locations are presented in Table 2.

3.3. Vitamin content of honey samples

Table 3: Vitamin content result of honey samples from the study sites

	Vitamin A	Vitamin B1	Vitamin B2	Vitamin B3	Vitamin B6	Vitamin B12	Vitamin C
FUTO	13.00	3.40	3.20	0.21	3.40	13.10	21.67
	13.50	2.98	3.50	0.34	3.50	13.00	22.10
	14.00	3.00	3.00	0.29	3.20	12.80	21.38
Mean±S.E	13.50±0.29^{a}	3.13±0.14^{b}	3.23±0.15^{de}	0.28±0.04^{f}	3.37±0.09^{g}	12.97±0.09^{h}	21.72±0.21^{i}
Nekede	14.01	3.80	3.50	0.24	3.60	12.80	21.68
	14.09	3.10	3.70	0.28	3.45	12.40	21.20
	13.99	2.99	3.57	0.30	3.50	13.00	22.00
Mean±S.E	14.03±0.03^{a}	3.30±0.25^{b}	3.59±0.06^{d}	0.27±0.02^{f}	3.52±0.04^{g}	12.73±0.18^{h}	21.63±0.23^{i}
Avu	13.70	3.50	3.60	0.27	3.70	13.00	22.80
	13.80	3.60	3.00	0.30	3.60	12.70	22.30
	14.00	3.70	3.20	0.34	3.80	13.20	22.50
Mean±S.E	13.83±0.09^{a}	3.60±0.06^{bc}	3.27±0.18^{de}	0.30±0.02^{f}	3.70±0.06^{g}	12.97±0.15^{h}	22.53±0.15^{j}
Umuguma	14.16	4.00	2.80	0.20	3.80	12.50	19.80
	14.11	4.30	2.70	0.22	3.90	12.20	19.00
	14.00	4.20	2.80	0.19	2.80	13.00	19.40
Mean±S.E	14.09±0.05^{a}	4.17±0.09^{c}	2.77±0.03^{e}	0.20±0.01^{f}	3.50±0.35^{g}	12.57±0.23^{h}	19.40±0.23^{k}
LSD value	0.50	0.50	0.39	0.08	0.60	0.55	0.68

NB.: means with the same superscript in the same column are not significantly different, $\alpha = 0.05$

The highest mean (14.09±0.05 mg/100g) vitamin A was recorded for Umuguma followed by Nekede (14.03±0.03 mg/100g). The least mean (13.50±0.29 mg/100g) vitamin A was recorded for FUTO. With respect to vitamin B_1, the highest value of 4.17±0.09 mg/100g was recorded for Umuguma followed by 3.60±0.06 mg/100g recorded for Avu. The least value of 3.13±0.14 mg/100g was recorded for FUTO.

The result for vitamin B_2 showed that honey samples from Nekede had the highest mean value of 3.59±0.06 mg/100g followed by Avu (3.27±0.18 mg/100g). The least value of 2.77±0.03 mg/100g was recorded for Umuguma. The highest mean value vitamin B_3 of 0.30±0.02 mg/100g was recorded for Avu followed by FUTO (0.28±0.04 mg/100g). The least mean vitamin B_3 value of 0.20±0.01 mg/100g was recorded for Umuguma. The result for vitamin B_6 showed that honey samples from Avu had the highest mean value of 3.70±0.06 mg/100g followed by Nekede (3.52±0.04 mg/100g). The least value of 3.37±0.09 mg/100g was recorded for FUTO. The highest mean values of vitamin B_{12} of 12.97±0.09 mg/100g and 12.97±0.15 mg/100g were recorded for FUTO and Avu respectively, followed by Nekede

(12.73±0.18 mg/100g). The least mean vitamin B_{12} value of 12.57±0.23 mg/100g was recorded for Umuguma. The result for vitamin C showed that honey samples from Avu had the highest mean value of 22.53±0.15 mg/100g followed by FUTO (21.72±0.21 mg/100g). The least value of 19.40±0.23 mg/100g was recorded for Umuguma.

With regards to vitamins A, B_3, B_6 and B_{12}, mean values of honey samples from FUTO, Nekede, Avu and Umuguma were not significantly different from each other. The mean vitamin B_1 value of honey samples from FUTO, Nekede and Avu were not significantly different from each other. However, mean vitamin B_1 value of honey samples from Umuguma was statistically different from those of FUTO and Nekede but do not differ significantly with the samples from Avu. Details of the mean separation are shown in Table 3.

The mean values for vitamin B_1, B_2, B_3, B_6 and C obtained from the selected locations did not conform with the work of Motuma and Bekesho (2016), being that the values of vitamins were so small. The result of vitamin C ranges from 19.40±0.23 mg/100g to 22.53±0.15 mg/100g, and this corroborates the work of Fatimah *et al*. (2013) that reported ranges of 18.52 ± 5.46 to 25.16 ± 2.33 mg/100g. The result revealed that there were significant differences ($p<0.05$) in mean vitamins B_1, B_2 and C. Conversely, there were no significant differences ($p>0.05$) in mean vitamins A, B_3, B_6 and B_{12} among the locations. The results of mean separations (LSD tests) for the vitamin content of honey samples from the selected locations are presented in Table 3.

3.4. Physical properties of honey samples

Table 4: Physical properties' result of honey samples from the study sites

	VISCOSITY (cP)	DENSITY (g/ml)
FUTO	1490.00	1.40
	1500.00	1.50
	1670.00	1.40
Mean±S.E	1553.33±58.40^a	1.43±0.03^b
Nekede	1494.00	1.70
	1509.00	1.50
	1545.00	1.50
Mean±S.E	1516.00±15.13^a	1.57±0.07^b
Avu	1502.00	1.60
	1490.00	1.60
	1480.00	1.50
Mean±S.E	1490.67±6.36^a	1.57±0.03^b
Umuguma	1489.00	1.40
	1492.00	1.30
	1400.00	1.50
Mean±S.E	1460.33±30.18^a	1.40±0.06^b
LSD value	110.69	0.16

NB.: means with the same superscript in the same column are not significantly different, α = 0.05

The highest mean value viscosity of 1553.33±58.40 cP was recorded for FUTO followed by the value recorded for Nekede (1516.00±15.13 cP). The least mean viscosity of 1460.33±30.18 cP was recorded for Umuguma. With respect to density, the highest mean values of 1.57±0.07 g/ml and 1.57±0.03 g/ml was recorded for Nekede and Avu respectively,

followed by a mean value (1.43±0.03 g/ml) recorded for FUTO. The least mean value of 1.40±0.06 g/ml was recorded for Umuguma. The result showed that mean viscosity and density were not significantly different among the locations as recorded in Table 4.

4. Conclusion

The study indicated that honey samples from the study sites have moderate to high protein, ash, fat, brix, mineral and vitamin content, and are thus highly recommended for consumption and nutrition. Similarly the high viscosity and density of honey from the selected locations indicate honey of better quality. The variations in the proximate analysis, mineral content, vitamins and physical properties of different honey qualities may be influenced by factors such as the geographical and botanical origin of the flora species, type and activity of bees, the extraction and handling technique employed and the storage condition. This study was limited to locations in Owerri-West Local Government Area of Imo State. More studies should be conducted to ascertain the variations in proximate composition among the major agro-ecological zones of Imo State. We recommended that factors that cause variations in honey be singled out for investigations in subsequent studies.

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